Amendments to the Specification

The paragraph starting at page 1, line 24 and ending at page 2, line 15 has been amended as follows.

Generally, an ink-jet printing apparatus has a carriage holding a printhead and an ink tank, conveyance means for conveying a print medium such as a print sheet, and control means for controlling these elements. In the ink-jet printing apparatus, printing is performed by scanning an ink-jet printhead (~~hereinbelow~~ hereinafter referred to as a "printhead"), having plural ink discharge ~~orifices~~ nozzles (~~hereinbelow~~ hereinafter referred to as "nozzles") to discharge ink droplets, in a direction (main scanning direction) ~~vertical~~ perpendicular to a print medium conveyance direction (subscanning direction) while ink is discharged to the print medium. At this time, as a large number of nozzles to discharge ink are arrayed on a straight line in the subscanning direction, printing is performed for a width corresponding to the number of nozzles by scanning of the printhead on the print medium once. Accordingly, the printing speed can be easily increased by increasing the number of nozzles and increasing the printing width of the printhead.

The paragraph starting at page 4, line 1 and ending at line 13 has been amended as follows.

When all the printing elements belonging to a time-divisionally driven group are driven, i.e., when the number of concurrently-driven printing elements is a

maximum (when the drive voltage drop is maximum), in order to realize stable ink discharge, the energy applied to the printhead is determined in consideration of the maximum number of concurrently-driven printing elements. However, in the case where the energy applied to the printhead is determined in this manner, if only one printing element is driven, excessive energy is applied to the printing element, ~~and~~ which harmfully affects the durability of the printing element.

The paragraph starting at page 4, line 25 and ending at page 26, line 9 has been amended as follows.

In recent years, there is an increasing need for higher image quality, and in response to the need, the size of discharged ink droplets ~~are~~ is reduced ~~in~~ using various methods in the ink-jet apparatus. For example, if printing is performed on a print sheet using small size ~~of~~ ink droplets, a high-quality image without graininess can be obtained in a low printing duty area, while in a high printing duty area, as an image with sufficient density cannot be formed by one ink discharge, the image must be formed by ~~plural times of~~ more than one ink discharge. As a result, the printing speed is lowered.

The paragraph starting at page 6, line 9 and ending at line 17 has been amended as follows.

In this manner, in a printing apparatus which forms an image using ink droplets in plural ~~ink~~ sizes, the voltage drop values, which occur in the printing elements used for discharging the respective size ink droplets, are different. Accordingly, it is desirable to set an optimum drive parameter to define the drive pulse to be applied to the printing elements in correspondence with the number of concurrently-driven printing elements.

The paragraph starting at page 10, line 9 and ending at line 20 has been amended as follows.

In accordance with the present invention as described above, in a case where printing is performed by discharging ink to a print medium from an ink-jet printhead having plural printing elements, capable of discharging ink droplets in plural ~~different~~ sizes, the number of concurrently-driven printing elements among printing elements corresponding to the respective one of the plural sizes of ink droplets is counted based on input print data, then based on the counted result, a drive pulse to be applied to the concurrently-driven printing elements is determined, and the drive pulse is applied to the concurrently-driven printing elements.

The paragraph starting at page 10, line 21 and ending at line 24 has been amended as follows.

The invention is particularly advantageous since an optimum drive pulse can always be applied to printing elements corresponding to the respective one of plural sizes of ink ~~droplet~~ droplets.

The paragraph starting at page 12, line 24 and ending at page 13, line 5 has been amended as follows.

In this specification, the terms "print" and "printing" not only include the formation of significant information such as characters and graphics, but also broadly ~~includes~~ include the formation of images, figures, patterns, and the like on a print medium, or the processing of the medium, regardless of whether they are significant or insignificant and whether they are so visualized as to be visually perceivable by humans.

The paragraph starting at page 13, line 20 and ending at line 23 has been amended as follows.

Fig. 1A is a perspective view showing the schematical structure of an ink-jet printing apparatus ~~(hereinbelow~~ (hereinafter, referred to as a "printing apparatus") as a typical embodiment of the present invention.

The paragraph starting at page 13, line 24 and ending at page 14, line 3 has been amended as follows.

A printhead 1 used in this embodiment discharges ink droplets by thermal energy, based on a method, among ink-jet printing methods, of particularly heating ink by using electrothermal transducers such as heat generation resistors as energy generation means, thereby ~~realizes~~ realizing high resolution and high accuracy in printed images.

The paragraph starting at page 15, line 6 and ending at line 18 has been amended as follows.

In Fig. 1A, on the right side of the main body of the printing apparatus, a recovery device 10 which performs recovery operation for maintaining a good ink discharge condition is provided. The recovery device 10 is provided with preliminary discharge orifices (not shown) for preliminary discharge for prevention of clogging on its side. The recovery device 10 includes a cap 11 for capping an ink discharge surface of the printhead 1, a wiper 12 for wiping the ink discharge surface of the printhead 1, a suction pump (not shown) for sucking ink from the ink discharge nozzles ~~(hereinbelow~~ (hereinafter referred to as "nozzles") of the printhead 1, and the like.

The paragraph starting at page 15, line 19 and ending at line 26 has been amended as follows.

Further, the printing apparatus of this embodiment has an encoder scale 13 and an encoder 14 to detect a moving speed of the carriage 2, and performs feed-back

control <u>of</u> the carriage motor 5 upon driving of the motor. Further, as the encoder 14 reads position information of the encoder scale 13, an ink discharge timing from the printhead 1 (hereinafter referred to as "heat timing") is obtained.

The paragraph starting at page 16, line 9 and ending at line 21 has been amended as follows.

In Fig. 1B, the nozzle array to discharge the black (Bk) ink includes a large diameter nozzle to discharge large ink droplets and a small diameter nozzle to discharge small ink droplets arranged alternately in its array direction (the conveyance direction of the print medium). The resolution between the large diameter nozzles is 300 dpi, and that between the small diameter nozzles is 300 dpi. The large diameter nozzles and the small diameter nozzles are respectively provided with a heater used for discharging large ink droplets ~~(hereinbelow~~ <u>(hereinafter,</u> "L heater") and a heater used for discharging small ink droplets ~~(hereinbelow~~ <u>(hereinafter,</u> "S heater").

The paragraph starting at page 16, line 24 and ending at page 17, line 4 has been amended as follows.

In the construction in Fig. 2, print data (color print data) sent from a host PC 106 is received by an interface ~~(hereinbelow~~ <u>(hereinafter</u> "I/F") control block 107 in the printing apparatus. The received data is bitmapped to print data of respective color

components (YMCBk), and the bitmap data are transferred to a DRAM 101 by a DMA controller 102 and temporarily stored in the DRAM 101 under the control of a CPU 110.

The paragraph starting at page 17, line 5 and ending at line 15 has been amended as follows.

The bitmapped print data stored in the DRAM 101 are read by the DMA 102, while an encoder signal is inputted for detection of the position of the printhead 1, and transferred to a head logic 105 of the printhead 1 via a sequence controller 104. At this time, the transferred data is outputted as print signals ~~(P_DATA 1~~ (P_DATA1 and ~~P_DATA 2~~ P_DATA2) in accordance with a clock signal (CLK) from the sequence controller 104. Then, after the data transfer, a latch signal (Latch Sig) is outputted to the head logic 105, and the print signals are latched by a latch circuit (not shown) in the head logic 105.

The paragraph starting at page 19, line 11 and ending at line 23 has been amended as follows.

On the other hand, as shown in Fig. 4, the print signal ~~P_DATA 1~~ P_DATA1 (in case of the head logic 105a) or the print signal ~~P_DATA 2~~ P_DATA2 (in case of the head logic 105b), serially inputted into an 8-bit shift register 203 in synchronization with the clock signal (CLK), is latched by an 8-bit latch circuit 202 by the

latch signal (Latch Sig). When the heat signal (Heat Sig) is supplied to an AND circuit 205, respective bits b0 to b7 of the latched 8-bit print signal are supplied to the eight drivers. In Fig. 4, the print signal is simply indicated as ~~P_DATA~~ PDATA without discrimination between the head logic 105a and the head logic 105b as a destination.

The paragraph starting at page 20, line 2 and ending at line 11 has been amended as follows.

Further, as shown in Fig. 4, in the dot counter 108a, the count value (Counter) is incremented when a count pulse (Count Pulse) generated based on the clock signal (CLK) and the print signal ~~(P_DATA)~~ (PDATA) are at a high level, and the count value is reset to "zero" when the latch signal (Latch Sig) becomes the high level. In this example, only one count output value is shown for simplicity of ~~explanation,~~ explanation; however, Lcount and Scount are actually outputted. Processing of the count outputs will be described in detail later.

The paragraph starting at page 21, line 16 and ending at line 23 has been amended as follows.

In double-pulse drive of performing ink discharge by application of double pulse preliminary ink heating performed by a pulse ~~ON_Time 1~~ ON_time1 (prepulse) attains more stable discharge. Further, ink discharge is actually performed by a pulse

~~ON_Time 2~~ ON_time2 (main pulse). In this embodiment, the pulse width of the main pulse is varied in accordance with the number of concurrently-driven printing elements.

The paragraph starting at page 21, line 24 and ending at line 26 has been amended as follows.

Note that as the pulse width modulation, all of the prepulse and ~~OFF_Time 1~~ OFF_time1 (off-time) as well as the main pulse may be varied.

The paragraph starting at page 23, line 13 and ending at line 22 has been amended as follows.

The heat table 111' is referred to using the outputs from the dot calculator 109, LHtable and SHtable. For example, in the above-described example, if LHtable = 11 holds, a pulse table No. "11" shown in Fig. 10 is addressed and the corresponding L heater ~~ON_Time 2~~ ON_Time2 is read, and if SHtable = 18 holds, a pulse table No. "18" is addressed, and the corresponding S heater ~~ON_Time 2~~ ON_Time2 is read. That is, the main pulse width for L heater is 2.20 ~~μS~~ μs and the main pulse width for S heater is 2.14 μs.

The paragraph starting at page 24, line 11 and ending at line 21 has been amended as follows.

At step S103, the dot counter 108b counts the number of dots which cause ink discharge in one of the respective blocks of the printhead, based on the read print signal, and at step 5104, the dot calculator 109 ~~multiples~~ multiplies the counted number of dots by the ~~above described~~ above-described coefficients. Then at step S105, in correspondence with the values (LHtable and SHtable) resulted from the multiplication, a parameter value (in this embodiment, the main pulse width is ~~ON_Time 2~~ ON_Time2) for defining the drive pulse is read from the heat table 111'.

The paragraph starting at page 24, line 22 and ending at page 25, line 1 has been amended as follows.

At step S106, the sequence controller 104 generates heat pulses with the read main pulse width, and transfers the heat pulses with the L heater print signal ~~(P-Data 1)~~ (P-Data1) and the S heater print signal ~~(P-Data 2)~~ (P-Data2) to the head logic 105 in the printhead 1. At step S107, printing is performed for one block of printing elements in the printhead 1.

The paragraph starting at page 25, line 17 and ending at line 25 has been amended as follows.

As described above, according to the embodiment, even in a case where printing is performed by using a printhead having heaters for discharging large size ~~of~~ ink

droplets and heaters for discharging small size ~~of~~ ink droplets, optimum drive pulses are applied to the respective heaters in correspondence with the number of concurrently-driven heaters. This arrangement controls voltage drop which occurs in the respective printing elements, and this results in stable printing density.

The paragraph starting at page 26, line 6 and ending at line 21 has been amended as follows.

Further, in the printhead according to the above described embodiment, the large diameter nozzles for discharging large size ~~of~~ ink droplets and the small diameter nozzles for discharging small size ~~of~~ ink droplets are alternately arranged in the nozzle array direction, and the large diameter nozzles and the small diameter nozzles are respectively provided with heaters for discharging large size ~~of~~ ink droplets and heaters for discharging small size ~~of~~ ink ~~droplets, however,~~ droplets. However, the present invention is not limited to this printhead. For example, the present invention is applicable to a printhead where each nozzle has a heater for discharging large ink droplets and a heater for discharging small ink droplets such that different sizes of ink droplets can be discharged from each nozzle by drop modulation.

The paragraph starting at page 27, line 11 and ending at page 28, line 7 has been amended as follows.

As the typical arrangement and principle of the ink-jet printing system, one practiced by use of the basic principle disclosed in, for example, U.S. Patent Nos. 4,723,129 and 4,740,796 is preferable. The above system is applicable to either one of so-called ~~an~~ on demand ~~type~~ and ~~a~~ continuous ~~type~~ types. Particularly, in the case of the on-demand type, the system is effective because, by applying at least one driving signal, which corresponds to printing information and causes a rapid temperature rise exceeding nucleate boiling, to each of electrothermal transducers arranged in correspondence with a sheet or liquid channels holding a liquid (ink), heat energy is generated by the electrothermal transducer to effect film boiling on the heat acting surface of the printhead, and consequently, a bubble can be formed in the liquid (ink) in one-to-one correspondence with the driving signal. By discharging the liquid (ink) through a discharge opening by growth and shrinkage of the bubble, at least one droplet is formed. If the driving signal is applied as a pulse signal, the growth and shrinkage of the bubble can be attained instantly and adequately to achieve discharge of the liquid (ink) with particularly high response characteristics.